CLAIMS

What is claimed is:

1. A fluid transfer assembly comprising:

a fluid carrier defining a fluid carrier volume, the fluid carrier having a distal end and a proximal end, the distal end configured to insert within a body lumen; and

a heat exchange assembly coupled to the proximal end of the fluid carrier, the heat exchange assembly having:

at least one heat exchange conduit in fluid communication with the fluid carrier;

a heat exchanger in thermal communication with the heat exchange conduit; and

a pump in fluid communication with the fluid carrier and in fluid communication with the at least one heat exchange conduit, the pump defining a stroke volume greater than the fluid carrier volume defined by the fluid carrier.

2. The fluid transfer assembly of claim 1 wherein the fluid carrier volume of the fluid carrier is less than between 30% and 60% of the stroke volume defined by the pump.

3. The fluid transfer assembly of claim 1 wherein the heat exchange conduit defines a heat exchange conduit volume greater than the stroke volume defined by the pump.

4. The fluid transfer assembly of claim 1 wherein the heat exchange assembly comprises a fluid inlet check valve in fluid communication with the fluid carrier, in fluid communication with the pump, and in fluid communication with a fluid inlet of the at least one heat exchange conduit, the fluid inlet check valve configured to:

(i) engage a first position during a fluid intake stroke of the pump, the first

position of the fluid inlet check valve directing a fluid from the fluid carrier to the pump; and

(ii) engage a second position during a fluid output stroke of the pump, the second position of the fluid inlet check valve directing the fluid from the pump to the fluid inlet of the at least one heat exchange conduit.

5. The fluid transfer assembly of claim 4 wherein the fluid inlet check valve comprises a flexible membrane that defines a substantially curved flow path between the pump and the fluid inlet of the at least one heat exchange conduit when the fluid inlet check valve engages the second position during the fluid output stroke of the pump.

6. The fluid transfer assembly of claim 1 wherein the heat exchange assembly comprises a fluid outlet check valve in fluid communication with the fluid carrier and in fluid communication with a fluid outlet of the at least one heat exchange conduit, the fluid outlet check valve configured to:

(i) engage a first position during a fluid intake stroke of the pump, the first position of the fluid outlet check valve limiting entry of a fluid from the fluid carrier to the fluid outlet of the at least one heat exchange conduit; and

(ii) engage a second position during a fluid output stroke of the pump, the second position of the fluid outlet check valve directing the fluid from the fluid outlet of the at least one heat exchange conduit to the fluid carrier.

7. The fluid transfer assembly of claim 6 wherein the fluid outlet check valve comprises a flexible membrane that defines a substantially curved flow path between the fluid outlet of the at least one heat exchange conduit and the fluid carrier when the fluid outlet check valve engages the second position during the fluid output stroke of the pump.

8. The fluid transfer assembly of claim 1 wherein the heat exchange assembly defines a

substantially curved fluid outlet path, relative to a central axis defined by the heat exchange assembly, disposed between the fluid carrier and a fluid outlet of the at least one heat exchange conduit.

9. The fluid transfer assembly of claim 1 wherein the heat exchange conduit is configured as a coiled-shaped conduit relative to a central axis defined by the heat exchange assembly.

10. The fluid transfer assembly of claim 1 wherein the heat exchange conduit is configured as a substantially U-shaped conduit having a fluid inlet conduit, a bend conduit in communication with the fluid inlet conduit, and an outlet conduit in communication with the bend conduit, the fluid inlet conduit and the fluid outlet conduit substantially parallel to a central axis defined by the heat exchange assembly.

11. The fluid transfer assembly of claim 1 wherein the heat exchange assembly comprises a first check valve in fluid communication with the fluid carrier, in fluid communication with the pump, and in fluid communication with a fluid inlet of the at least one heat exchange conduit, the first check valve configured to:

(i) engage a first position during a fluid intake stroke of the pump, the first position of the first check valve directing a fluid from the fluid carrier to the fluid inlet of the at least one heat exchange conduit; and

(ii) engage a second position during a fluid output stroke of the pump, the second position of the first check valve directing the fluid from the pump to the fluid carrier.

12. The fluid transfer assembly of claim 1 wherein the heat exchange assembly comprises a second check valve in fluid communication with the pump and in fluid communication with a fluid outlet of the at least one heat exchange conduit, the second check valve configured to:

(i) engage a first position during a fluid intake stroke of the pump, the first position of the second check valve directing a fluid from the fluid outlet of the at least one heat exchange conduit to the pump; and

(ii) engage a second position during a fluid output stroke of the pump, the second position of the second check valve limiting entry of the fluid from the pump to the fluid outlet of the at least one heat exchange conduit.

13. The fluid transfer assembly of claim 1 wherein the heat exchange assembly comprises a sensor in fluid communication with the fluid carrier, the sensor chosen from the group consisting of a temperature sensor, a blood flow rate sensor, a bubble sensor, or a clot detection sensor.

14. The fluid transfer assembly of claim 1 wherein the fluid carrier comprises a catheter defining a lumen, the catheter configured to:

(i) provide fluid, via the lumen, from the body lumen and to the heat exchange assembly during a fluid intake stroke of the pump; and

(ii) deliver fluid, via the lumen, from the heat exchange assembly and to the body lumen during a fluid output stroke of the pump.

15. The fluid transfer assembly of claim 1 wherein the fluid carrier comprises a catheter configured to insert within a carotid artery of a body.

16. The fluid transfer assembly of claim 15 wherein the catheter has a diameter between 4 French and 18 French.

17. The fluid transfer assembly of claim 1 wherein the fluid carrier comprises a double-lumen catheter defining a first lumen and a second lumen, the catheter configured to:

(i) provide fluid, via the first lumen, from the body lumen and to the heat exchange assembly during a fluid intake stroke of the pump; and

(ii) deliver fluid, via the second lumen, from the heat exchange assembly and to a body lumen during a fluid output stroke of the pump.

18. The fluid transfer assembly of claim 1 wherein the fluid carrier comprises priming assembly configured to introduce fluid into, and remove air from, the heat exchange conduit.

19. A fluid transfer system comprising:

a fluid carrier defining a fluid carrier volume, the fluid carrier having a distal end and a proximal end, the distal end configured to insert within a body lumen;

a heat exchange assembly coupled to the proximal end of the fluid carrier, the heat exchange assembly having:

at least one heat exchange conduit in fluid communication with the fluid carrier,

a heat exchanger in thermal communication with the heat exchange conduit, and

a pump in fluid communication with the fluid carrier and in fluid communication with the at least one heat exchange conduit, the pump defining a stroke volume greater than the fluid carrier volume defined by the fluid carrier; and

a console coupled to the heat exchange assembly, the console configured to circulate a thermal exchange fluid within the heat exchanger of the heat exchange assembly.

20. The fluid transfer system of claim 19 wherein the fluid carrier volume of the fluid carrier is less than between 30% and 60% of the stroke volume defined by the pump.

21. The fluid transfer system of claim 19 wherein the heat exchange conduit defines a

heat exchange conduit volume greater than the stroke volume defined by the pump.

22. The fluid transfer system of claim 19 wherein the heat exchange assembly comprises a fluid inlet check valve in fluid communication with the fluid carrier, in fluid communication with the pump, and in fluid communication with a fluid inlet of the at least one heat exchange conduit, the fluid inlet check valve configured to:

(i) engage a first position during a fluid intake stroke of the pump, the first position of the fluid inlet check valve directing a fluid from the fluid carrier to the pump; and

(ii) engage a second position during a fluid output stroke of the pump, the second position of the fluid inlet check valve directing the fluid from the pump to the fluid inlet of the at least one heat exchange conduit.

23. The fluid transfer system of claim 22 wherein the fluid inlet check valve comprises a flexible membrane that defines a substantially curved flow path between the pump and the fluid inlet of the at least one heat exchange conduit when the fluid inlet check valve engages the second position during the fluid output stroke of the pump.

24. The fluid transfer system of claim 19 wherein the heat exchange assembly comprises a fluid outlet check valve in fluid communication with the fluid carrier and in fluid communication with a fluid outlet of the at least one heat exchange conduit, the fluid outlet check valve configured to:

(i) engage a first position during a fluid intake stroke of the pump, the first position of the fluid outlet check valve limiting entry of the fluid from the fluid carrier to the fluid outlet of the at least one heat exchange conduit; and

(ii) engage a second position during a fluid output stroke of the pump, the second position of the fluid outlet check valve directing the fluid from the fluid outlet of the at least one heat exchange conduit to the fluid carrier.

25. The fluid transfer system of claim 24 wherein the fluid outlet check valve comprises a flexible membrane that defines a substantially curved flow path between the fluid outlet of the at least one heat exchange conduit and the fluid carrier when the fluid outlet check valve engages the second position during the fluid output stroke of the pump.

26. The fluid transfer system of claim 19 wherein the heat exchange assembly defines a substantially curved fluid outlet path, relative to a central axis defined by the heat exchange assembly, disposed between the fluid carrier and a fluid outlet of the at least one heat exchange conduit.

27. The fluid transfer system of claim 19 wherein the heat exchange conduit is configured as a coiled-shaped conduit relative to a central axis defined by the heat exchange assembly.

28. The fluid transfer system of claim 19 wherein the heat exchange conduit is configured as a substantially U-shaped conduit having a fluid inlet conduit, a bend conduit in communication with the fluid inlet conduit, and an outlet conduit in communication with the bend conduit, the fluid inlet conduit and the fluid outlet conduit substantially parallel to a central axis defined by the heat exchange assembly.

29. The fluid transfer system of claim 19 wherein the heat exchange assembly comprises a first check valve in fluid communication with the fluid carrier, in fluid communication with the pump, and in fluid communication with a fluid inlet of the at least one heat exchange conduit, the first check valve configured to:

(i) engage a first position during a fluid intake stroke of the pump, the first position of the first check valve directing a fluid from the fluid carrier to the fluid inlet of the at least one heat exchange conduit; and

(ii) engage a second position during a fluid output stroke of the pump, the second position of the first check valve directing the fluid from the pump to the fluid carrier.

30. The fluid transfer system of claim 19 wherein the heat exchange assembly comprises a second check valve in fluid communication with the pump and in fluid communication with a fluid outlet of the at least one heat exchange conduit, the second check valve configured to:

(i) engage a first position during a fluid intake stroke of the pump, the first position of the second check valve directing the fluid from the fluid outlet of the at least one heat exchange conduit to the pump; and

(ii) engage a second position during a fluid output stroke of the pump, the second position of the second check valve limiting entry of the fluid from the pump to the fluid outlet of the at least one heat exchange conduit.

31. The fluid transfer system of claim 19 wherein the heat exchange assembly comprises a sensor in fluid communication with the fluid carrier and in electrical communication with the console, the sensor chosen from the group consisting of a temperature sensor, a blood flow rate sensor, a bubble sensor, or a clot detection sensor.

32. The fluid transfer system of claim 19 wherein the fluid carrier comprises a catheter defining a lumen, the catheter configured to:

(i) provide fluid, via the lumen, from the body lumen and to the heat exchange assembly during a fluid intake stroke of the pump; and

(ii) deliver fluid, via the lumen, from the heat exchange assembly and to the body lumen during a fluid output stroke of the pump.

33. The fluid transfer system of claim 19 wherein the fluid carrier comprises a catheter configured to insert within a carotid artery of a body.

34. The fluid transfer system of claim 33 wherein the catheter has a diameter between 4 French and 18 French.

35. The fluid transfer system of claim 19 wherein the fluid carrier comprises a double-lumen catheter defining a first lumen and a second lumen, the catheter configured to:

(i) provide fluid, via the first lumen, from the body lumen and to the heat exchange assembly during a fluid intake stroke of the pump; and

(ii) deliver fluid, via the second lumen, from the heat exchange assembly and to a body lumen during a fluid output stroke of the pump.

36. The fluid transfer assembly of claim 19 wherein the fluid carrier comprises priming assembly configured to introduce fluid into, and remove air from, the heat exchange conduit.

37. A heat exchange assembly configured to couple in fluid communication with a fluid carrier, a distal end of the fluid carrier configured to insert within a body lumen, the heat exchange assembly comprising:

at least one heat exchange conduit defining a heat exchange conduit volume;

a heat exchanger in thermal communication with the heat exchange conduit; and

a pump in fluid communication with the at least one heat exchange conduit, the pump defining a stroke volume, the heat exchange conduit volume defined by the heat exchange conduit being greater than the stroke volume defined by the pump.

38. The heat exchange assembly of claim 37 comprising a fluid inlet check valve configured to couple in fluid communication with the fluid carrier, in fluid communication with the pump, and in fluid communication with a fluid inlet of the at least one heat exchange conduit, the fluid inlet check valve configured to:

(i) engage a first position during a fluid intake stroke of the pump, the first

position of the fluid inlet check valve configured to direct a fluid from the fluid carrier to the pump; and

(ii) engage a second position during a fluid output stroke of the pump, the second position of the fluid inlet check valve directing the fluid from the pump to the fluid inlet of the at least one heat exchange conduit.

39. The heat exchange assembly of claim 38 wherein the fluid inlet check valve comprises a flexible membrane that defines a substantially curved flow path between the pump and the fluid inlet of the at least one heat exchange conduit when the fluid inlet check valve engages the second position during the fluid output stroke of the pump.

40. The heat exchange assembly of claim 37 wherein the heat exchange assembly comprises a fluid outlet check valve configured to couple in fluid communication with the fluid carrier and in fluid communication with a fluid outlet of the at least one heat exchange conduit, the fluid outlet check valve configured to:

(i) engage a first position during a fluid intake stroke of the pump, the first position of the fluid outlet check valve configured to limit entry of a fluid from the fluid carrier to the fluid outlet of the at least one heat exchange conduit; and

(ii) engage a second position during a fluid output stroke of the pump, the second position of the fluid outlet check valve directing the fluid from the fluid outlet of the at least one heat exchange conduit to the fluid carrier.

41. The heat exchange assembly of claim 40 wherein the fluid outlet check valve comprises a flexible membrane that defines a substantially curved flow path between the fluid outlet of the at least one heat exchange conduit and the fluid carrier when the fluid outlet check valve engages the second position during the fluid output stroke of the pump.

42. The heat exchange assembly of claim 37 wherein the heat exchange assembly defines

a substantially curved fluid outlet path, relative to a central axis defined by the heat exchange assembly, disposed between the fluid carrier and a fluid outlet of the at least one heat exchange conduit.

43. The heat exchange assembly of claim 37 wherein the heat exchange conduit is configured as a coiled-shaped conduit relative to a central axis defined by the heat exchange assembly.

44. The heat exchange assembly of claim 37 wherein the heat exchange conduit is configured as a substantially U-shaped conduit having a fluid inlet conduit, a bend conduit in communication with the fluid inlet conduit, and an outlet conduit in communication with the bend conduit, the fluid inlet conduit and the fluid outlet conduit substantially parallel to a central axis defined by the heat exchange assembly.

45. The heat exchange assembly of claim 37 comprising a sensor in fluid communication with the fluid carrier, the sensor chosen from the group consisting of a temperature sensor, a blood flow rate sensor, a bubble sensor, or a clot detection sensor.

46. A method for obtaining a therapeutic temperature in a body comprising:

inserting a distal end of a fluid carrier within a body lumen;

coupling a proximal end of the fluid carrier to a heat exchange assembly, the heat exchange assembly having at least one heat exchange conduit in fluid communication with the fluid carrier, a heat exchanger in thermal communication with the heat exchange conduit, and a pump in fluid communication with the fluid carrier and in fluid communication with the at least one heat exchange conduit, the pump defining a stroke volume greater than a fluid carrier volume defined by the fluid carrier;

withdrawing fluid from the body lumen, through the fluid carrier and into the heat exchange conduit, by the pump to thermally modify the fluid by the thermal

communication between the heat exchange conduit and the heat exchanger; and

introducing the thermally modified fluid to the body lumen.

47. The method of claim 46 further comprising:

detecting the temperature of the body; and

repeating the steps of withdrawing, modifying, and introducing until a detected body temperature is substantially equal to a preset therapeutic temperature.

48. The method of claim 46 wherein the step of inserting comprises inserting a distal end of a catheter within a carotid artery of a body and further comprising selectively cooling a head of the body by:

withdrawing blood from the body lumen, through the catheter and into the heat exchange conduit, by the pump;

cooling the blood by the thermal communication between the heat exchange conduit and the heat exchanger; and

introducing the cooled blood to the body lumen.

49. A check valve assembly for transferring a fluid from a first region to a second region, the check valve assembly comprising:

a hydrodynamically shaped valve housing defining at least one fluid inlet path extending from a first fluid region to a second fluid region and defining at least one fluid outlet path extending from the second fluid region to the first fluid region;

a deformable inlet check valve coupled to the hydrodynamically shaped valve housing allowing passage of the fluid through the at least one fluid inlet path from the first fluid region to the second fluid region; and

a deformable outlet check valve coupled to the hydrodynamically shaped valve housing allowing passage of the fluid through the at least one fluid outlet path from the second fluid region to the first fluid region;

the deformable inlet check valve and deformable outlet check valve operable to define respective, substantially curved shapes allowing passage of fluid between the first fluid region and the second fluid region in a hydrodynamic manner.

50. The check valve assembly of claim 49 wherein the respective substantially curved shapes of the deformable inlet check valve and the deformable outlet check valve, in conjunction with the hydrodynamic shape of the check valve housing, are operable to allow passage of fluid between the first fluid region and the second fluid region in a non-destructive manner with respect to particles in the fluid.

51. The check valve assembly of claim 49 wherein the respective substantially curved shapes of the deformable inlet check valve and the deformable outlet check valve, in conjunction with the hydrodynamic shape of the check valve housing, are operable to allow laminar flow of fluid between the first fluid region and the second fluid region.